Data Acquisition with NI WSN Gateway and Nodes

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1. Introduction

The National Instruments Wireless Security Network (NI-WSN) 9791 gateway is a programmable Ethernet gateway that connects the remote NI-WSN nodes to a computer for data acquisition and control. The NI-WSN 3202 and the NI-WSN 3212 nodes are programmable wireless receivers housing several analog and digital inputs. These nodes can be connected to a variety of sensors including, but not limited to, ultrasonic sensors and infrared sensors. The objective of this project is to transmit data from various sensors via a wireless network to a computer running LabVIEW. To prove this concept we have designed a security system to be detailed below.

2. Device Description and Interface

2.1 Wireless Devices

The devices used in this project include:

- NI WSN 9791 Ethernet Gateway: used to route the connection from the nodes to the host computer
- NI WSN 3202 Node: used to relay data gathered from analog or digital sensors to the host computer
- NI WSN 3212 Node: used to relay data obtained from thermocouples or digital sensors to the host computer
- Parallax PING Ultrasonic Sensor: used to detect the proximity of an object.
- Parallax PIR Infrared Sensor: used to detect the proximity of an object using infrared signals
- Basic K-type Thermocouple: used to detect changes in temperature.
- LED Light: used to signal the triggering of an alarm.

NI WSN 9791 Ethernet Gateway. The Ethernet gateway shown in Fig. 1 can essentially be thought of as the bridge between the wireless nodes and the host computer. It connects to the host computer via an Ethernet cable to receive instructions from LabVIEW 2010+ and broadcast them to the nodes. Each node is synchronized with the gateway via the LabVIEW Measurement and Automation software package in LabVIEW.

Fig. 1. NI WSN 9791 Ethernet Gateway

NI WSN 3202 Wireless Node. The NI WSN 3202 Wireless Node shown in Fig. 2 is a programmable wireless receiver that transmits data from a sensor to the gateway. This particular node contains 4 analog and 4 digital inputs.

Fig. 2. NI WSN 3202 Wireless Node

NI WSN 3212 Wireless Node. The NI WSN 3212 Wireless Node shown in Fig. 3 is a programmable wireless receiver that, like the 3202, transmits data from a sensor to the gateway. This particular node contains 4 thermocouple inputs and 4 digital inputs.

Fig. 3. NI WSN 3212 Wireless Node

2.2 Wireless Standards

The wireless communication between nodes in accomplished with use of IEEE 802.15.4 standard. While the standard can be purchased, we gained free access to it via Wikipedia[5]. This standard specifies the physical layer and media access control for a low-rate wireless personal area network (LR-WPAN). The standard defines specifications for the fundamental lower network layers of a certain wireless personal area network (WPAN).

In general, the standard is intended for very low cost devices that communicate over a short range. The basic framework provides for a 10-meter range with an average transfer rate of 250 kbit/s. Initially, lower rates of transfer were considered, but later opted out of. 20 and 40 kbit/s were the initial definitions and 100 kbit/s is the current definition. Even lower rates can be achieved with less power consumption being the benefit. The standard allows for those low powered devices to utilize power management functions such as link quality and energy detection.

Important features of this standard include the ability of real time data transfer. This is accomplished by guaranteed reservation of time slots during transmissions. Additionally, the medium access involves Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA). The final contributor to real time suitability is the integrated support for secure communications.

As shown in Fig. 3.1, the protocol architecture uses a conceptually simple layered structure. The layers are based off of the Open Systems Interconnection Model (OSI model). The most common implementation of the IEEE 802.15.4 standard is the Zigbee network [6].

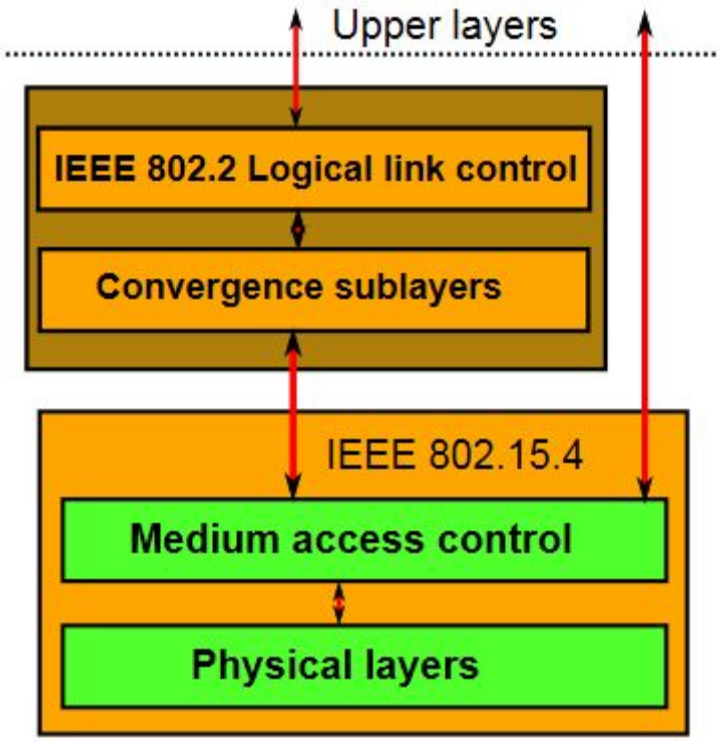

Fig 3.1. Stack protocol of IEEE 802.15.4 [5]

2.3 Sensing Devices and Peripherals

Parallax PING Ultrasonic Sensor. The Parallax PING Ultrasonic Sensor shown in Fig. 4 utilizes ultrasonic audio chirps to detect motion. The sensor connects to the analog input of the NI WSN 3202 wireless node.

Fig. 4. Parallax PING UltraSonic Sensor

Infrared Sensor. The infrared sensor shown in Fig. 5, provides data about the temperature of an object. Like the PING sensor, it connects to an analog port on the NI WSN 3202 wireless node.

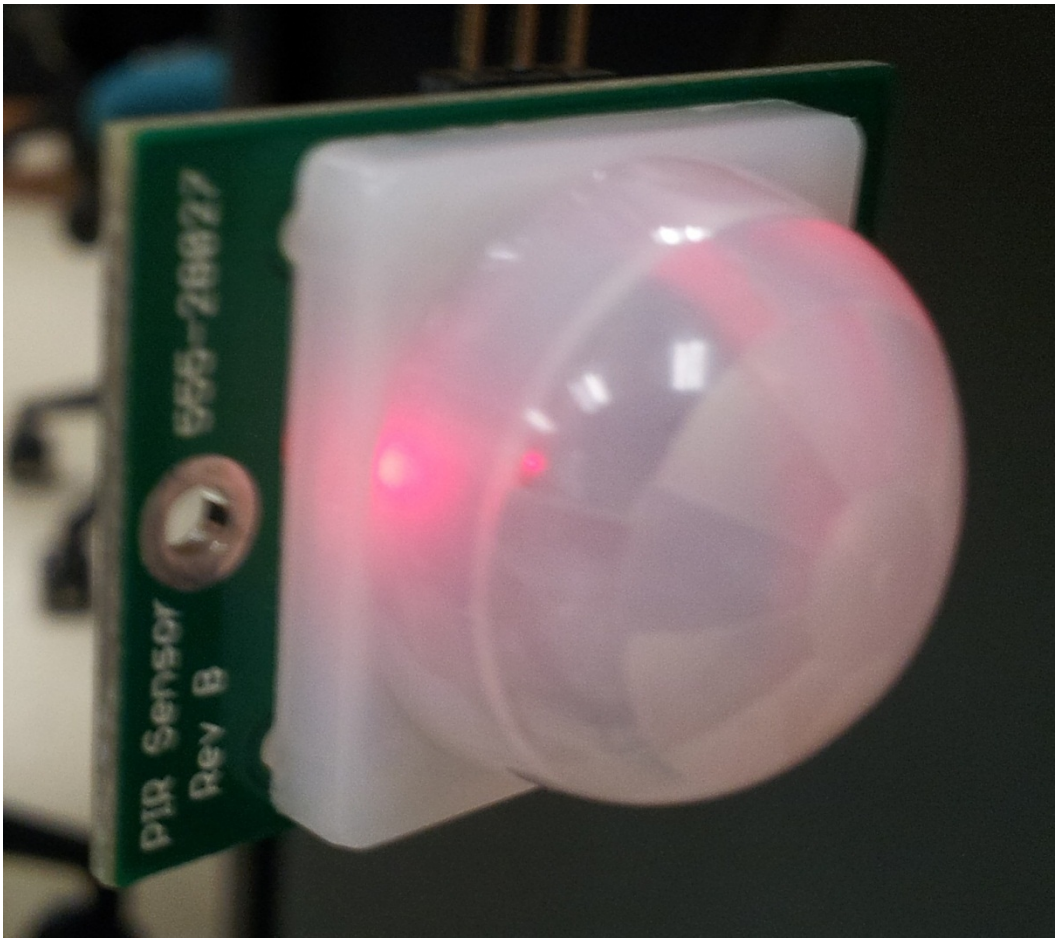

Fig. 5. Parallax PIR Infrared Sensor

Thermocouples Although, not used in this project, thermocouples (shown in Fig 6) are the default sensors delivered with this NI-WSN system.

Fig. 6 Thermocouple

3. Programming Principles

Each of the sensors is monitored via a LabVIEW 2010 programming. First, the sensor nodes must be connected to the Ethernet gateway via NI Measurement and Automation Explorer. To do so, follow the following steps:

- Open NI Measurement and Automation Explorer.
- Expand the Remote Systems Tree.
- The NI WSN 9791 Ethernet Gateway should automatically be detected. Click it.
- On the screen that appears after clicking the gateway, click the nodes tab.
- Click add nodes.
- Enter the type of node and the serial number of the node.
- Repeat for each additional node.

Once the nodes are added to the gateway, the user can now create an empty LabVIEW project. Once the project is created in LabVIEW, right click the project name. Select New >> Targets and Devices... Select Existing Targets or Devices and expand the WSN Gateway folder to choose the 9791 Ethernet Gateway configured in Measurement and Automation. The measurement nodes configured with the network are automatically added underneath the gateway in the LabVIEW Project, giving the user instant access to their I/O variables and properties.

Graphical programming of instruments is very different than in traditional text-based languages, specifically, the explicit sending of data to device registers. An equivalent operation in LabVIEW is performed by graphically connecting respective visual elements. For example, to connect the sensor data to an indicator, all one should do is drag the AI0 from the 3202's I/O tree on the left hand side of the screen onto the block

diagram and attach it to an indicator, shown in Fig. 7. More detailed information can be found in the User Manual section of this document.

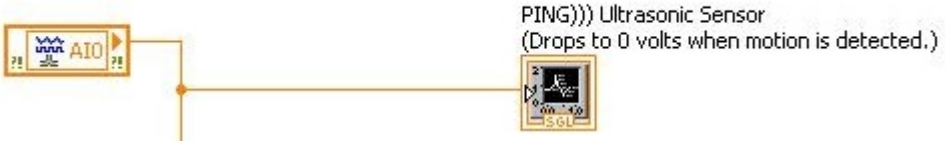

Fig. 7. Attaching input to an indicator

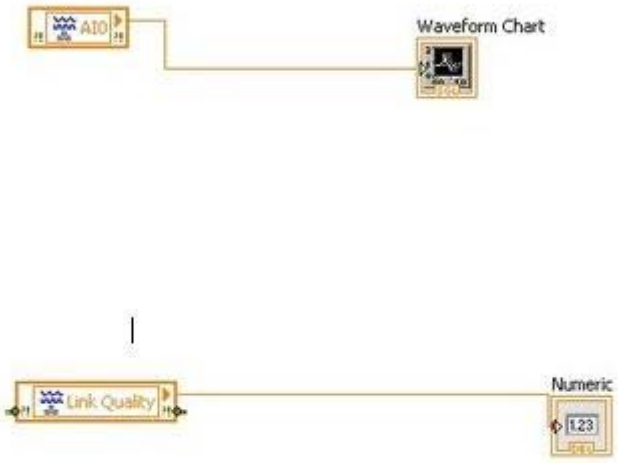

Fig. 8 Connecting shared variables.

In Figure 8, AI0 (or Analog Input 0) represents the sensor attached to the AI0 terminal on the NI-WSN 3202 node. It is attached to the Waveform Chart via a wire. This allows the user to graphically see the output of a sensor attached to the AI0 terminal. The link quality variable represents the strength of the signal between the NI-WSN 3202 node and the NI-WSN 9791 Ethernet Gateway and is attached to a Numeric Indicator to allow the user to determine if the Link Quality is too poor for their uses.

The logic to the program is fairly straight-forward. The selected programming API is LabVIEW G, a high level graphics based language with the ability to perform many of the same functions as Java, C, C++, and C#. Instead of a text based code, LabVIEW G programs are created graphically.

The ultrasonic sensor runs at a constant voltage of 0.5V when there is no motion detected. Once motion is detected, the voltage changes in either the positive or negative direction. Therefore, the pseudocode for the LabVIEW program at the time of writing this document looks as follows:

```
if (detectedVoltage < 4) {
    activateLED();
}
```

Similar logic can be applied to the infrared sensor:

```
if(detectedVoltage > 3) {
    activateLED();
}
```

The LabVIEW equivalent of these statements is:

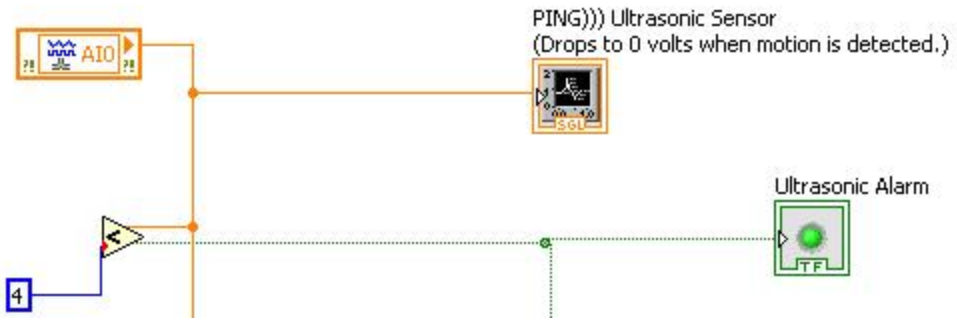

Fig. 9 LabVIEW equivalent to pseudocode

The sensor (AI0) is attached to both the graph and a comparator. The comparator compares the voltage obtained from the sensor to a constant (4). If the voltage is less than 4, it returns true and triggers the Ultrasonic alarm, otherwise it returns false and the alarm is not triggered.

4. Experimentation

A running example consists of the graphs displaying the correct voltage of both the ultrasonic sensor and the infrared sensor. In addition to this, when the desired result is obtained (motion detected/temperature achieved), turn on the LED in both LabView and the real world.

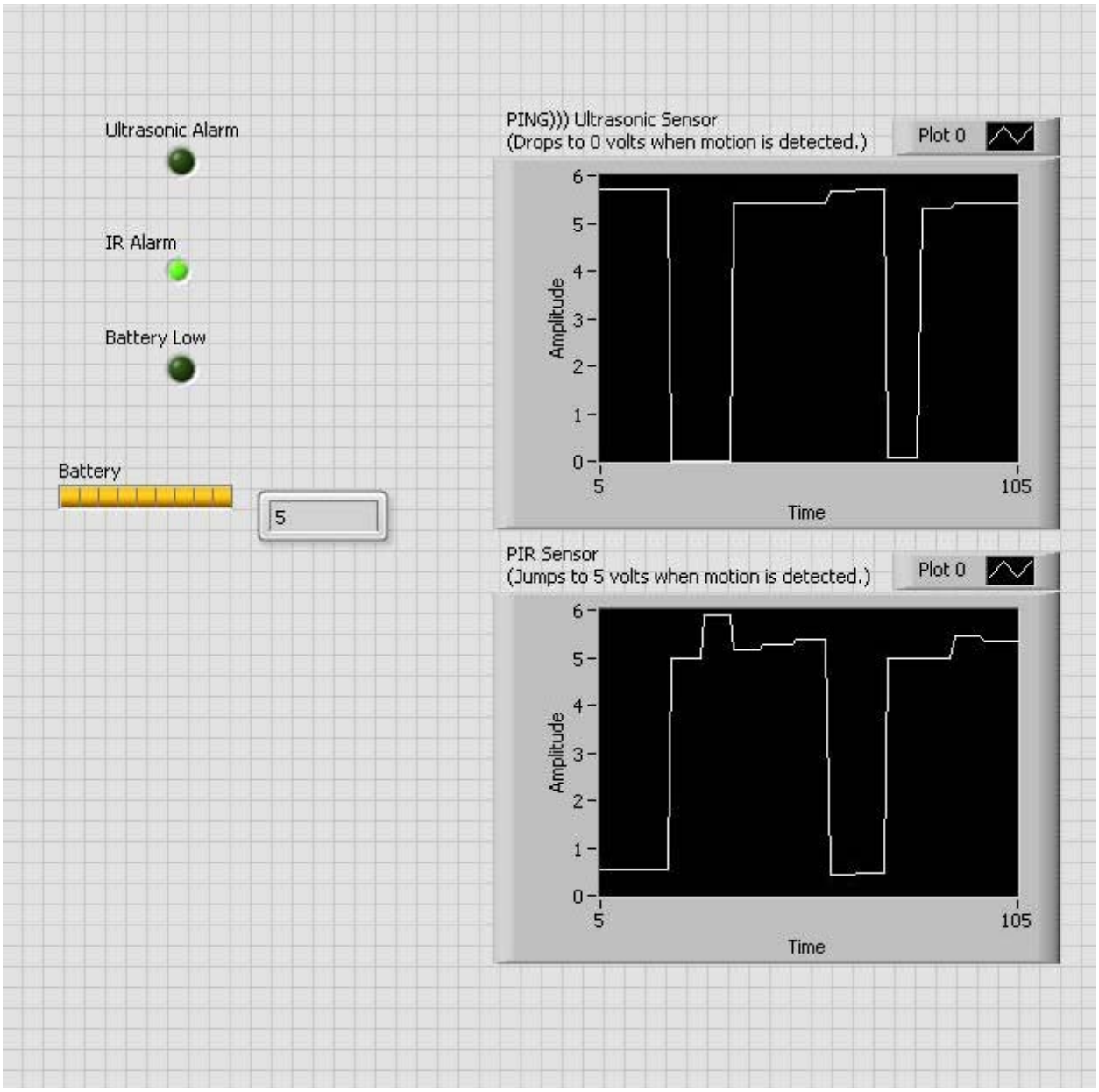

Fig. 9 Detection of motion and the triggering of the on screen LEDs

5. Conclusion

The most difficult hurdles to overcome in this project were damaged sensors, horrible and inaccurate documentation in previous products as well as the broken, non-working source code of the previous project, and the power limitations of the NI-WSN 3202 node (limit of two devices per node). As such, this project is, as of the time of writing, the first and only project at Florida Gulf Coast University dealing with the NI-WSN 3202 sensor node and the NI-WSN 9791 to be fully functional. In this project, we've learned how to program in LabVIEW as well as how to troubleshoot analog signals. Future projects could add another NI-WSN 3202 node and either more PIR and PING))) sensors or entirely different analog sensors.

6. References

[1] Parallax PING Ultrasonic Sensor Documentation:

http://www.parallax.com/Portals/0/Downloads/docs/prod/acc/28015-PING-v1.6.pdf

[2] Parallax PIR Sensor Documentation:

http://www.parallax.com/dl/docs/prod/audiovis/pirsensor-v1.2.pdf

[3] Getting Started with NI Wireless Sensor Networks:

http://zone.ni.com/devzone/cda/tut/p/id/8890

[4] IEEE 802.15.4 standard documentation:

http://standards.ieee.org/getieee802/download/802.15.4d-2009.pdf

[5] IEEE 802.15.4 stack protocol:

http://en.wikipedia.org/wiki/IEEE_802.15.4

[6] ZigBee Alliance Standards:

http://www.zigbee.org/Specifications/ZigBee/Overview.aspx

Appendix

User Manual

A1. Connecting the sensors to the NI-WSN 3202/NI-WSN 3212 nodes:

Connect the ultrasonic sensor to the 3202 node by connecting the power, ground, and signal wires to the SEN PWR, AI0 GND and AI0 terminals on the node respectively, as shown in Figure A1. Perform the same action for the IR sensor, using AI1 and AI1 ground instead (Fig. A2). If used, connect the thermocouple positive and negative to the NI WSN 3212 TC0+ and TC0- terminals respectively (Fig. A3).

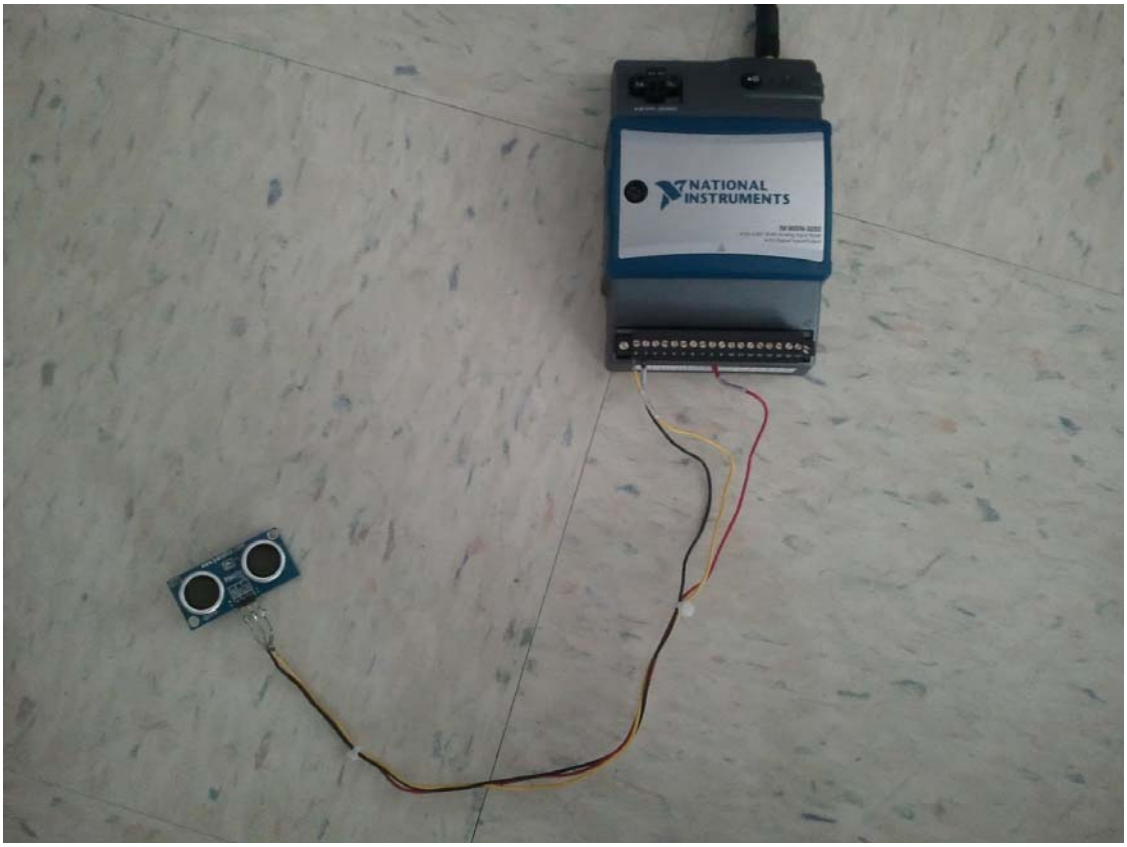

Fig. A1. PING Sensor attached to NI WSN 3202

Fig. A2. NI WSN 3202 with PIR Sensor attached.

Fig. A3. NI WSN 3212 with Thermocouple attached

Preparation of the environment to create a LabVIEW program is shown in Figures A4 through A13.

A2. Adding the nodes to the WSN 9791 ethernet gateway:

Preparation of the environment to create a LabVIEW program is shown in Figures A4 through A13.

Fig. A4. Click the start button.

Fig. A5. Choose all programs.

Fig. A6. Navigate to the National Instruments folder and choose Measurement and Automation.

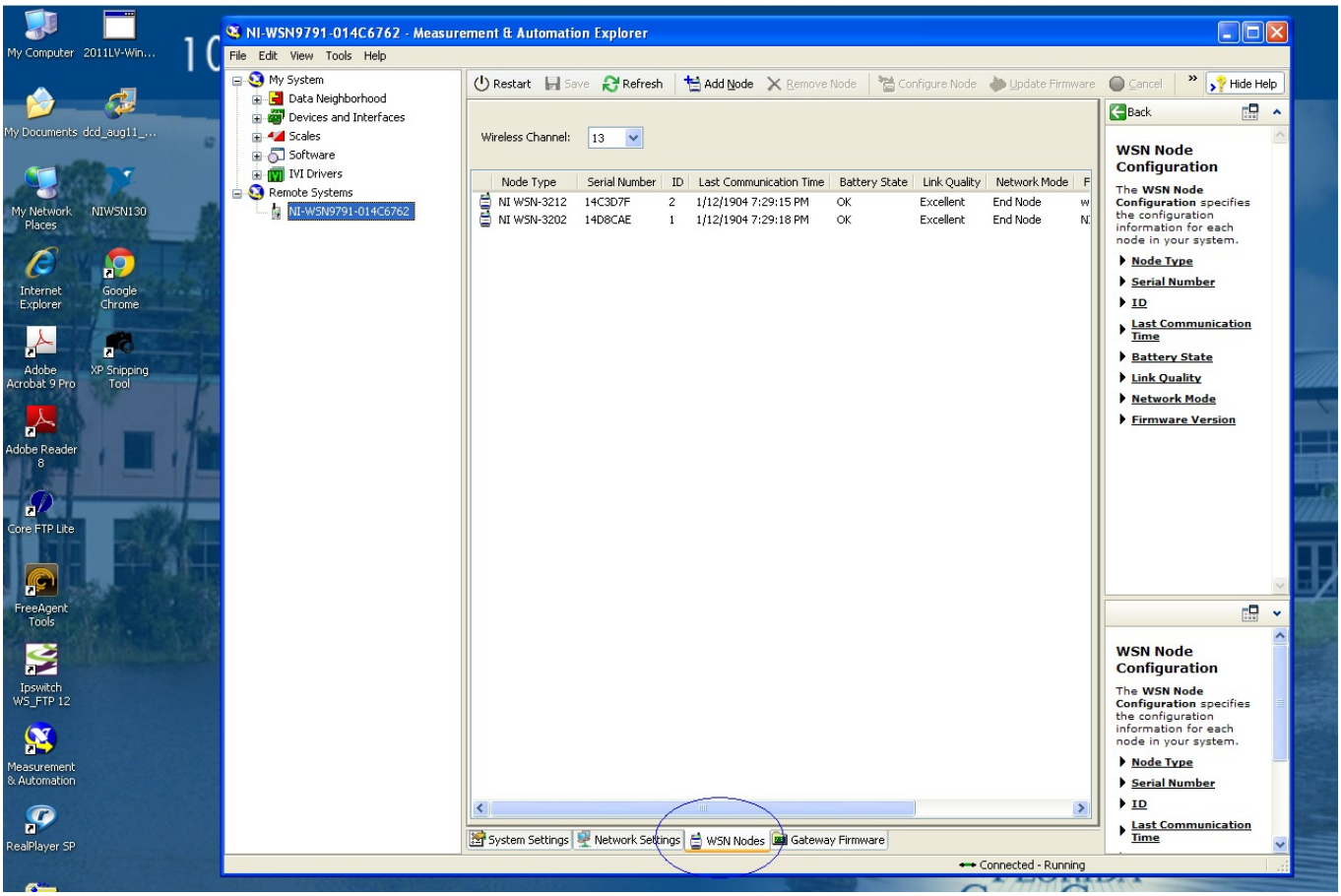
NI-WSN9791-014C6762 - Measurement & Automation Explorer
File Edit View Tools Help
My System
Data Neighborhood
Devices and Interfaces
Scales
Software
IVI Drivers
Remote Systems
NI-WSN9791-014C6762
Restart Save Refresh Add Node Remove Node Configure Node Update Firmware Cancel Hide Help
Wireless Channel: 13
Node Type Serial Number ID Last Communication Time Battery State Link Quality Network Mode
NI WSN-3212 14C3D7F 2 1/12/1904 7:29:15 PM OK Excellent End Node
NI WSN-3202 14D8CAE 1 1/12/1904 7:29:18 PM OK Excellent End Node
Back
WSN Node Configuration
The WSN Node Configuration specifies the configuration information for each node in your system.
Node Type
Serial Number
ID
Last Communication Time
Battery State
Link Quality
Network Mode
Firmware Version
System Settings Network Settings WSN Nodes Gateway Firmware
Connected - Running

Fig. A7. Expand the tree labeled Remote Systems. Select the NI-WSN Ethernet Gateway. On the bottom of the window, click the Nodes tab.

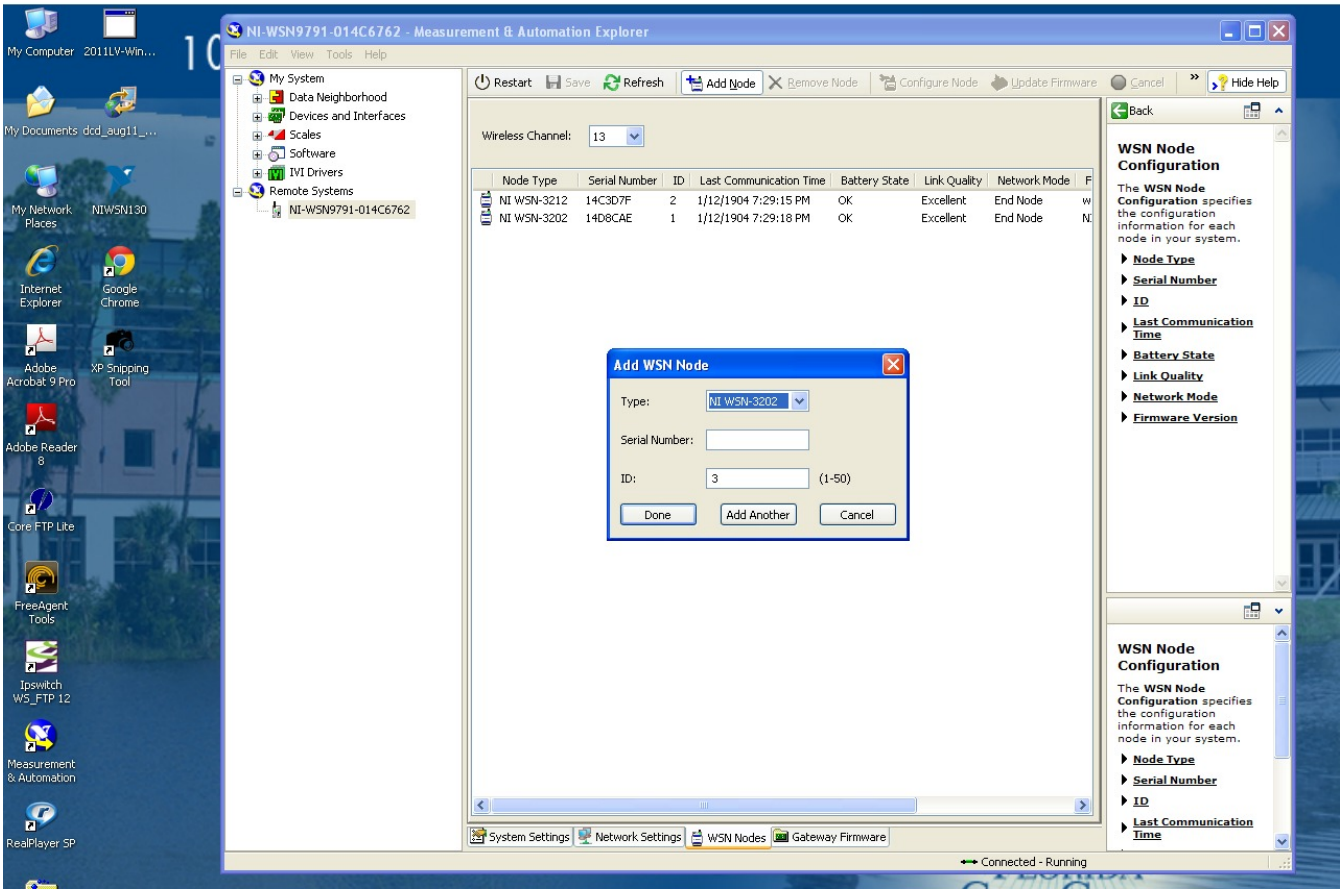

Fig. A8. On the top panel, click add nodes. In the window that appears, select the type of node (3202 or 3212), input the node's serial number (located on the back), and input a node

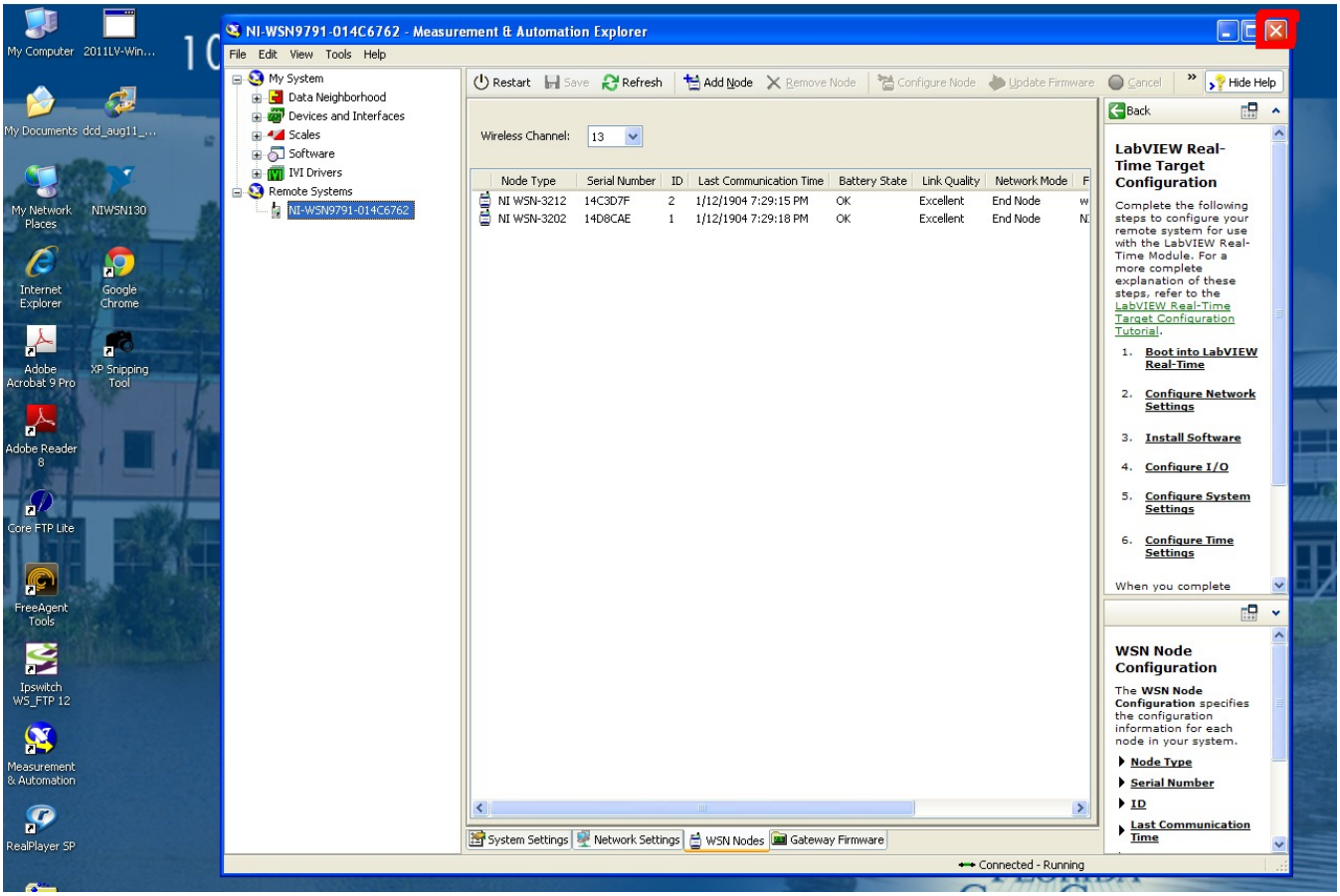
NI-WSN9791-014C6762 - Measurement & Automation Explorer
File Edit View Tools Help
My System
Data Neighborhood
Devices and Interfaces
Scales
Software
IVI Drivers
Remote Systems
NI-WSN9791-014C6762
Restart Save Refresh Add Node Remove Node Configure Node Update Firmware Cancel Hide Help
Wireless Channel: 13
Node Type Serial Number ID Last Communication Time Battery State Link Quality Network Mode
NI WSN-3212 14C3D7F 2 1/12/1904 7:29:15 PM OK Excellent End Node
NI WSN-3202 14D8CAE 1 1/12/1904 7:29:18 PM OK Excellent End Node
System Settings Network Settings WSN Nodes Gateway Firmware
Connected - Running
Back
LabVIEW Real-Time Target Configuration
Complete the following steps to configure your remote system for use with the LabVIEW Real-Time Module. For a more complete explanation of these steps, refer to the LabVIEW Real-Time Target Configuration Tutorial.
1. Boot into LabVIEW Real-Time
2. Configure Network Settings
3. Install Software
4. Configure I/O
5. Configure System Settings
6. Configure Time Settings
When you complete
WSN Node Configuration
The WSN Node Configuration specifies the configuration information for each node in your system.
Node Type
Serial Number
ID
Last Communication Time
My Computer
2011LV-Win...
My Documents
dcd_aug11_...
My Network Places
NIWSN130
Internet Explorer
Google Chrome
Adobe Acrobat 9 Pro
XP Snipping Tool
Adobe Reader 8
Core FTP Lite
FreeAgent Tools
Ipswitch WS_FTP 12
Measurement & Automation
RealPlayer SP

Fig. A9. ID (0-50). Close Measurement and Automation.

Import the nodes into LabVIEW:

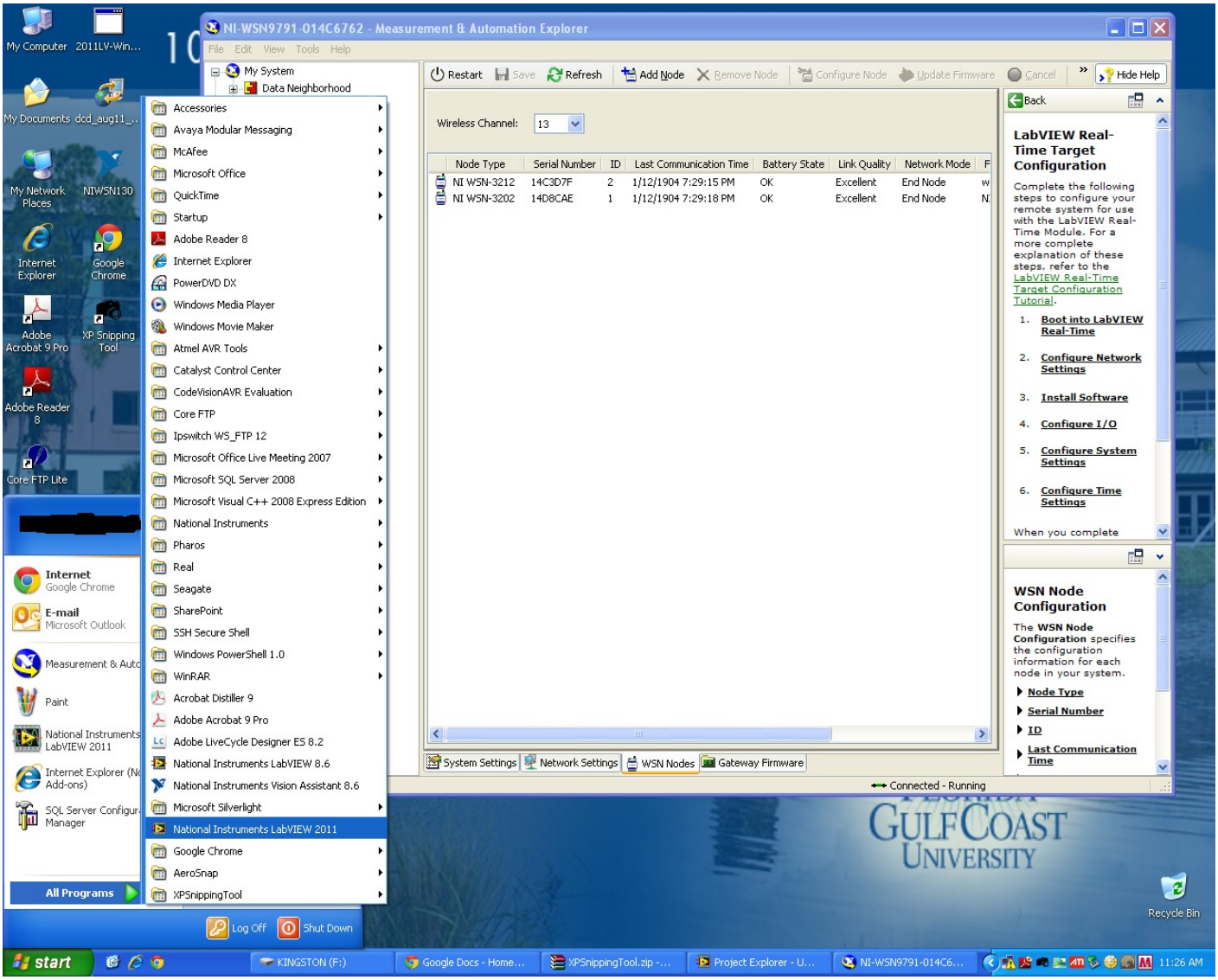

Fig. A10 Open LabVIEW by clicking Start >> All Programs >> National Instruments >>

(In our case, LabVIEW 2011).

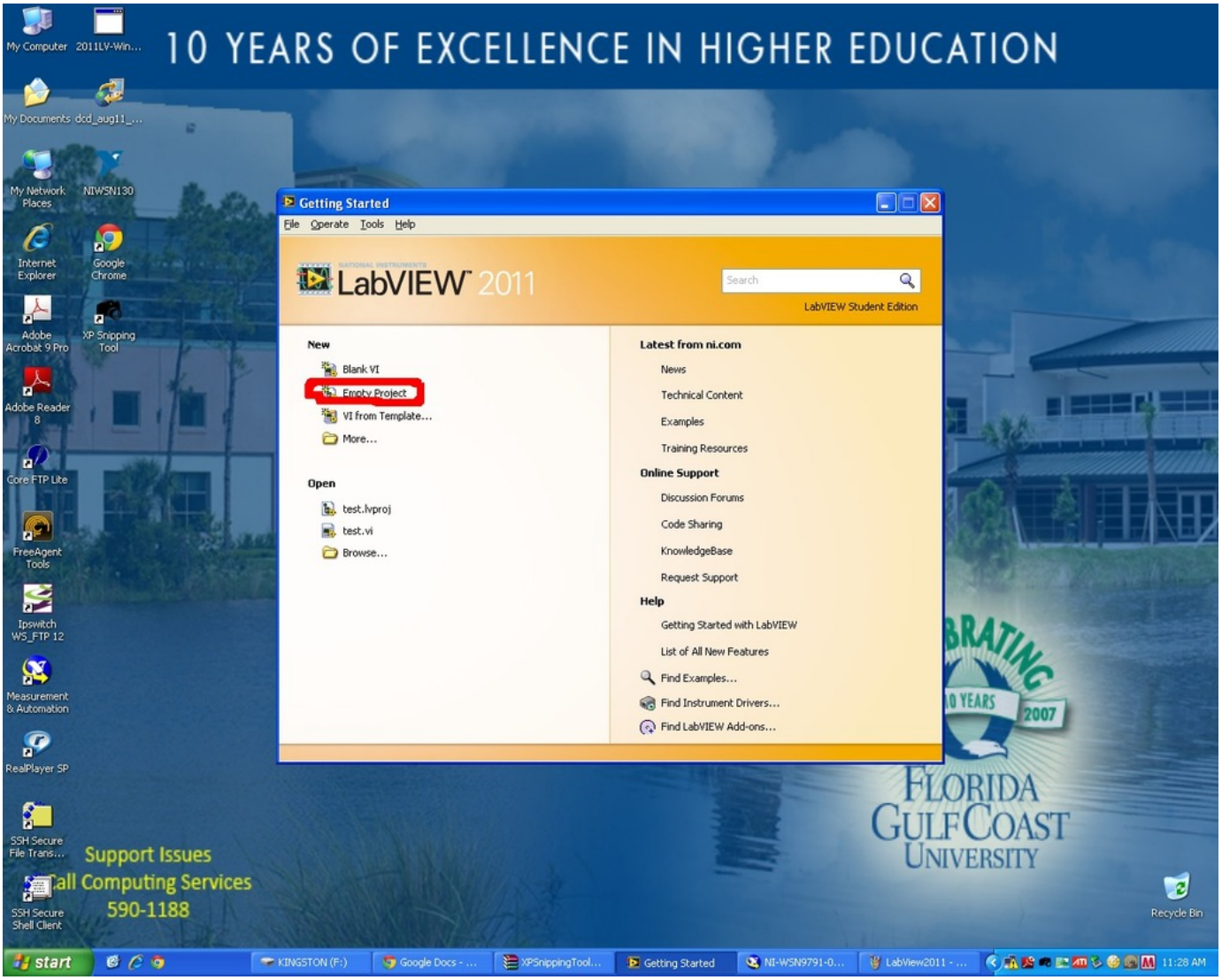

Fig. A11. On the screen that pops up, click Empty Project.

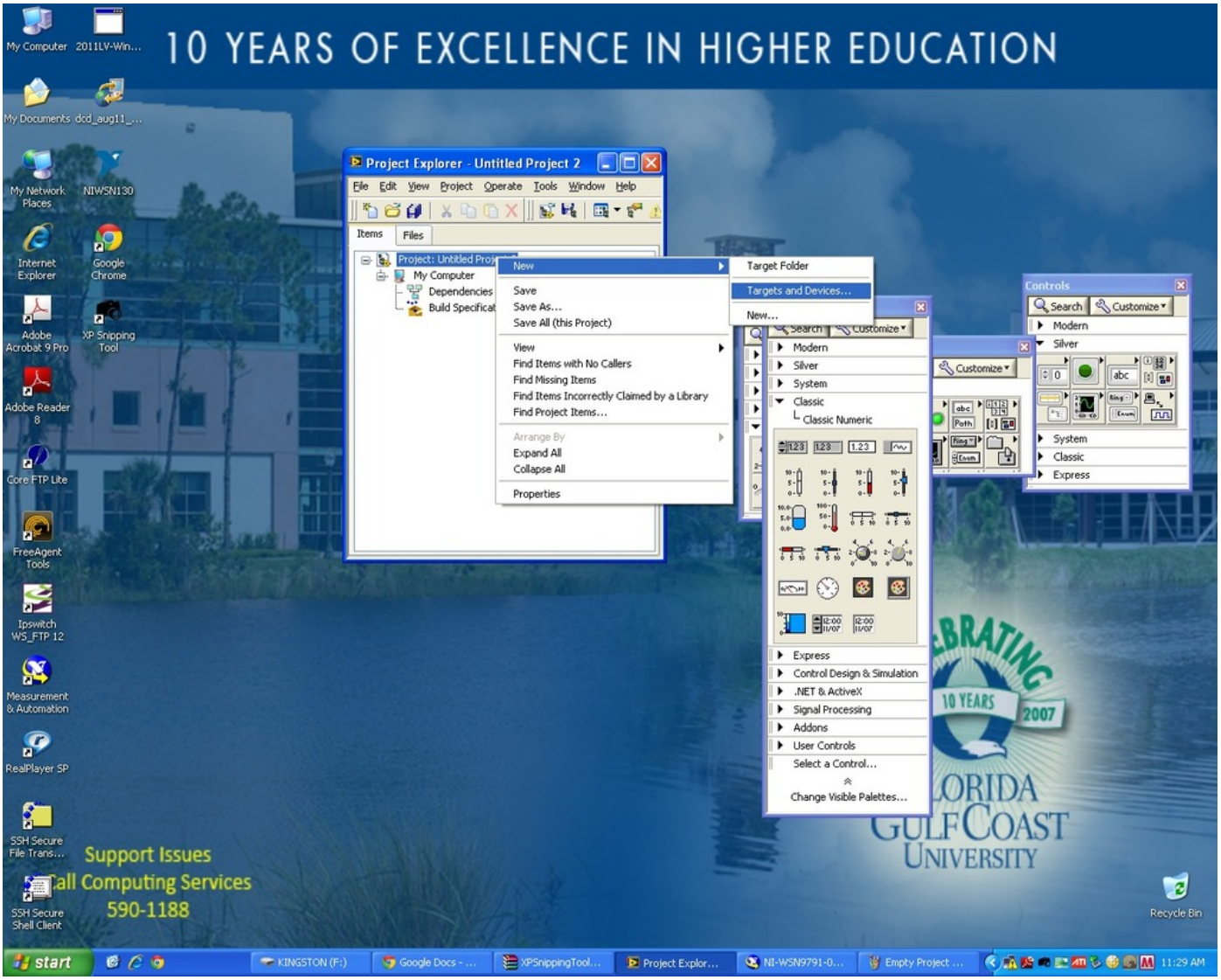

Fig. A12. In the next window, right click the project name and click New >> Targets and Devices.

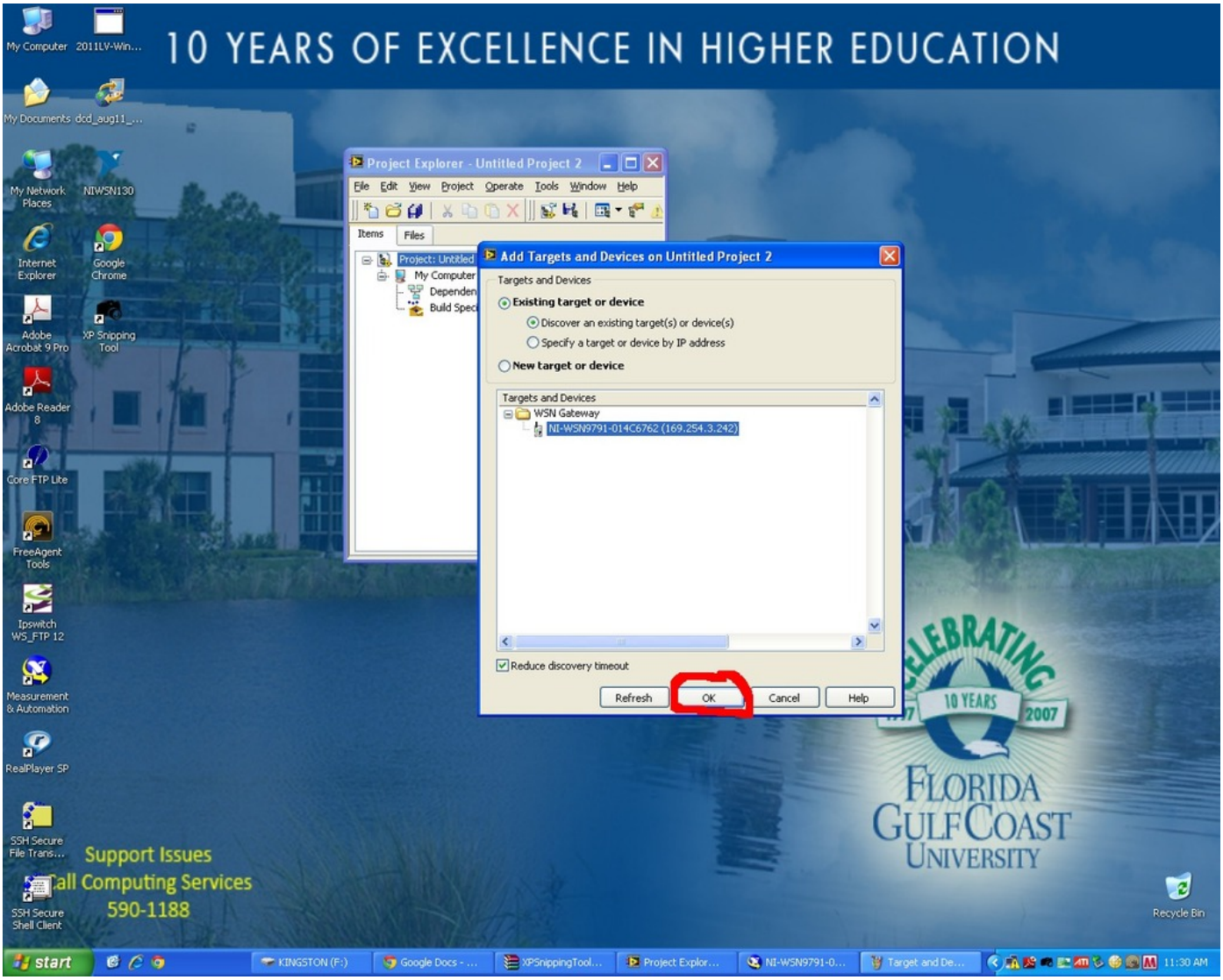

Fig. A13. In the Window that appears, expand the WSN Gateway tree and select the two nodes. Click ok.

A3. Creating the program:

Procedure for creating a LabVIEW program to detect motion from either the PING))) or PIR senor is explained step by step in Figures A14 through A24. It is shown for the PING sensor, but the same logic can be used for the PIR sensor as well as the thermocouple by replacing AI0 with AI1 or TC0 respectively. (TC0 is located in the Node 2 tree).

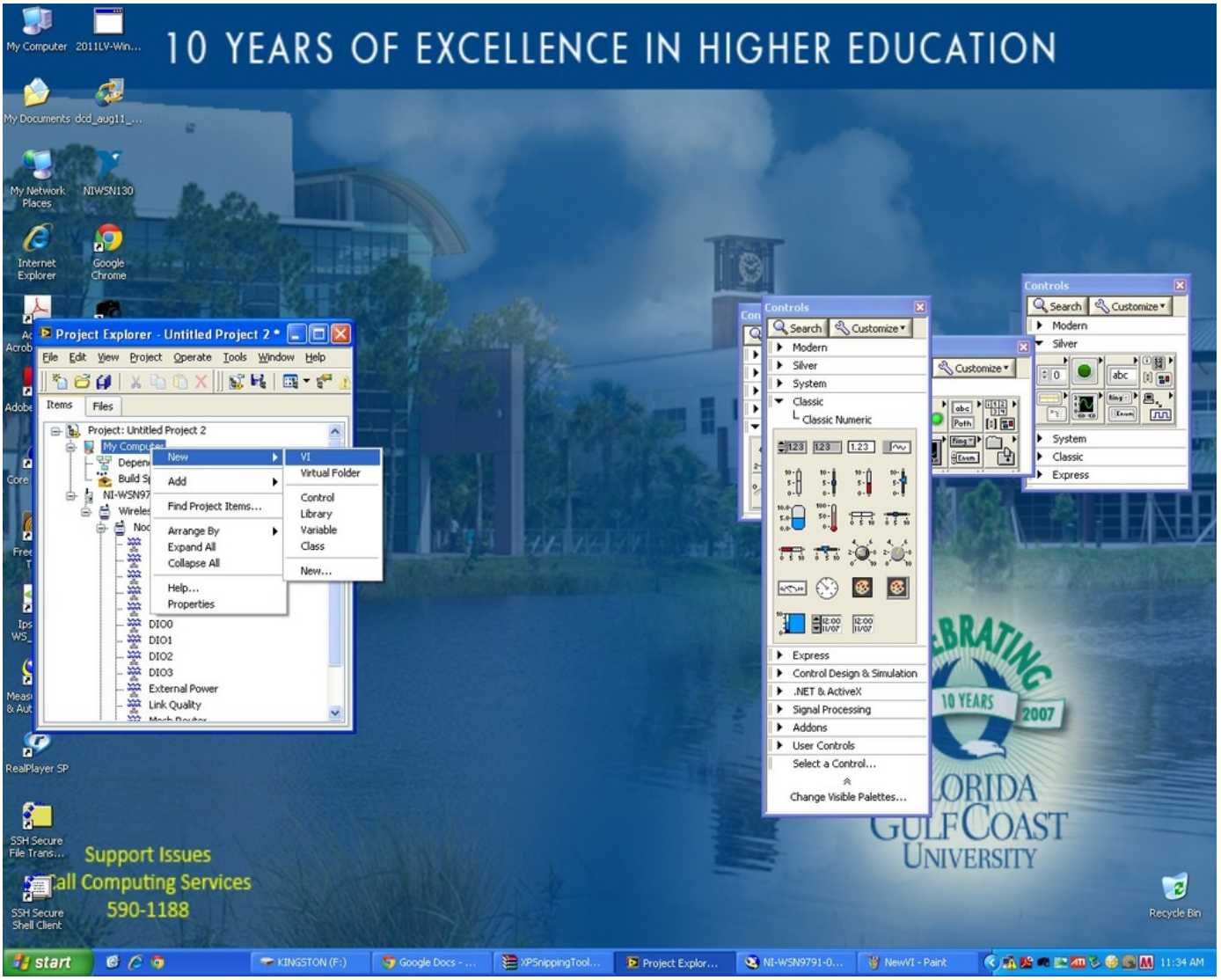

Fig. A14. The two nodes will automatically be imported into your LabVIEW program.

Next, right click My Computer (in the Project Explorer Window) and click New >> VI.

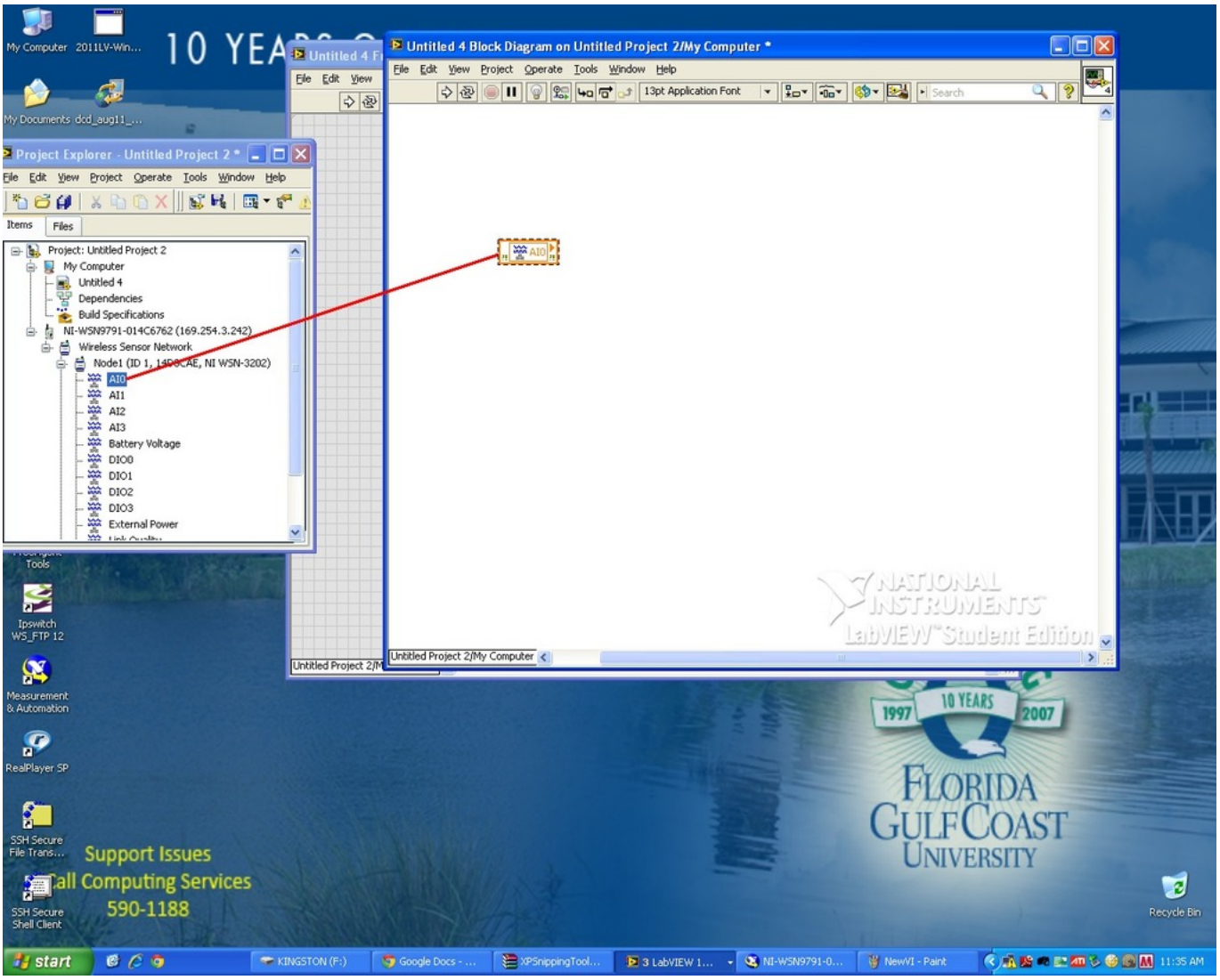

Fig. A15. Expand node 1 (1st input should be: AI0). Drag AI0 (Or Analog input that the Ultrasonic sensor is attached to) onto the block diagram.

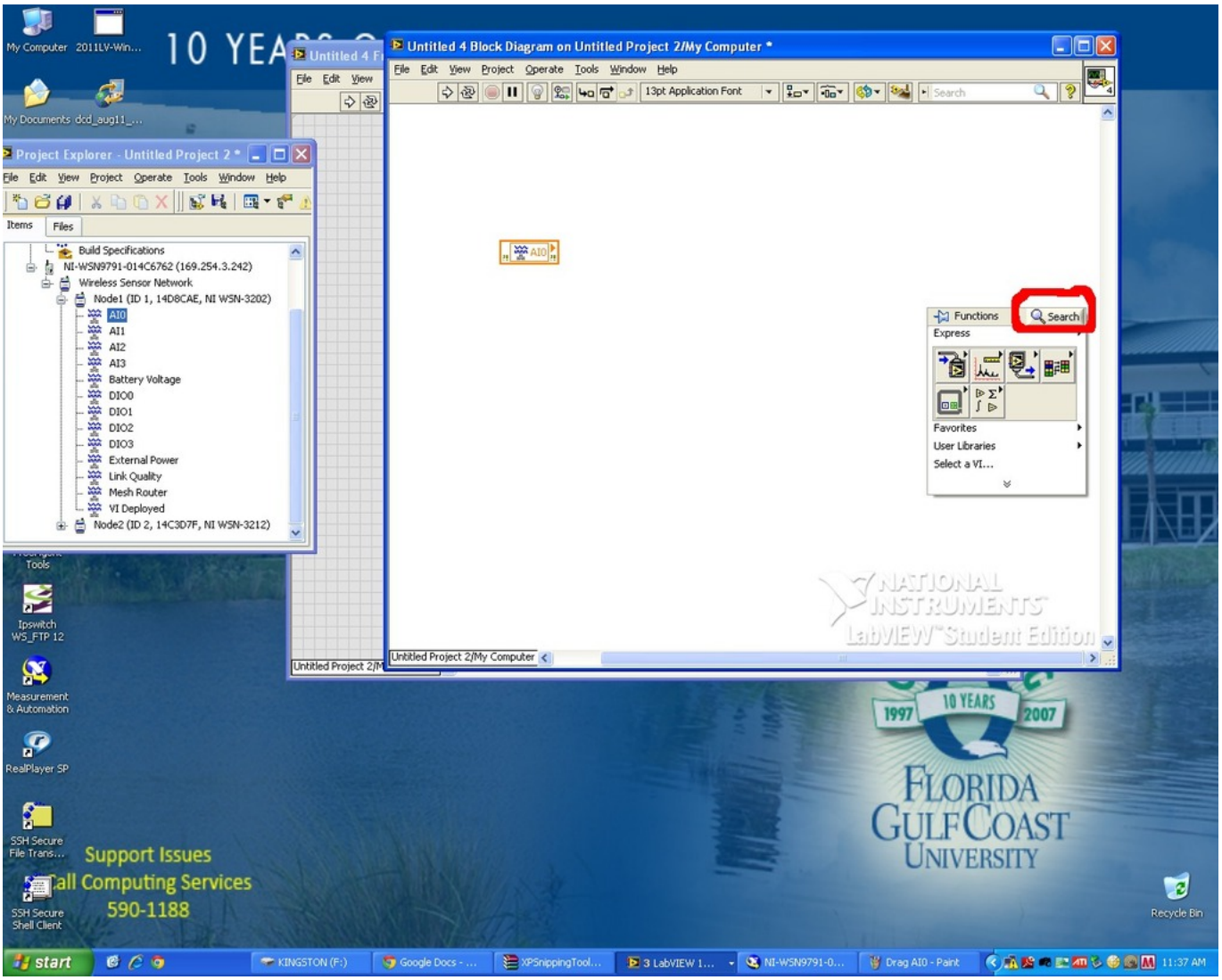

Fig. A16. Next, on the Front Panel, right click and click the search button.

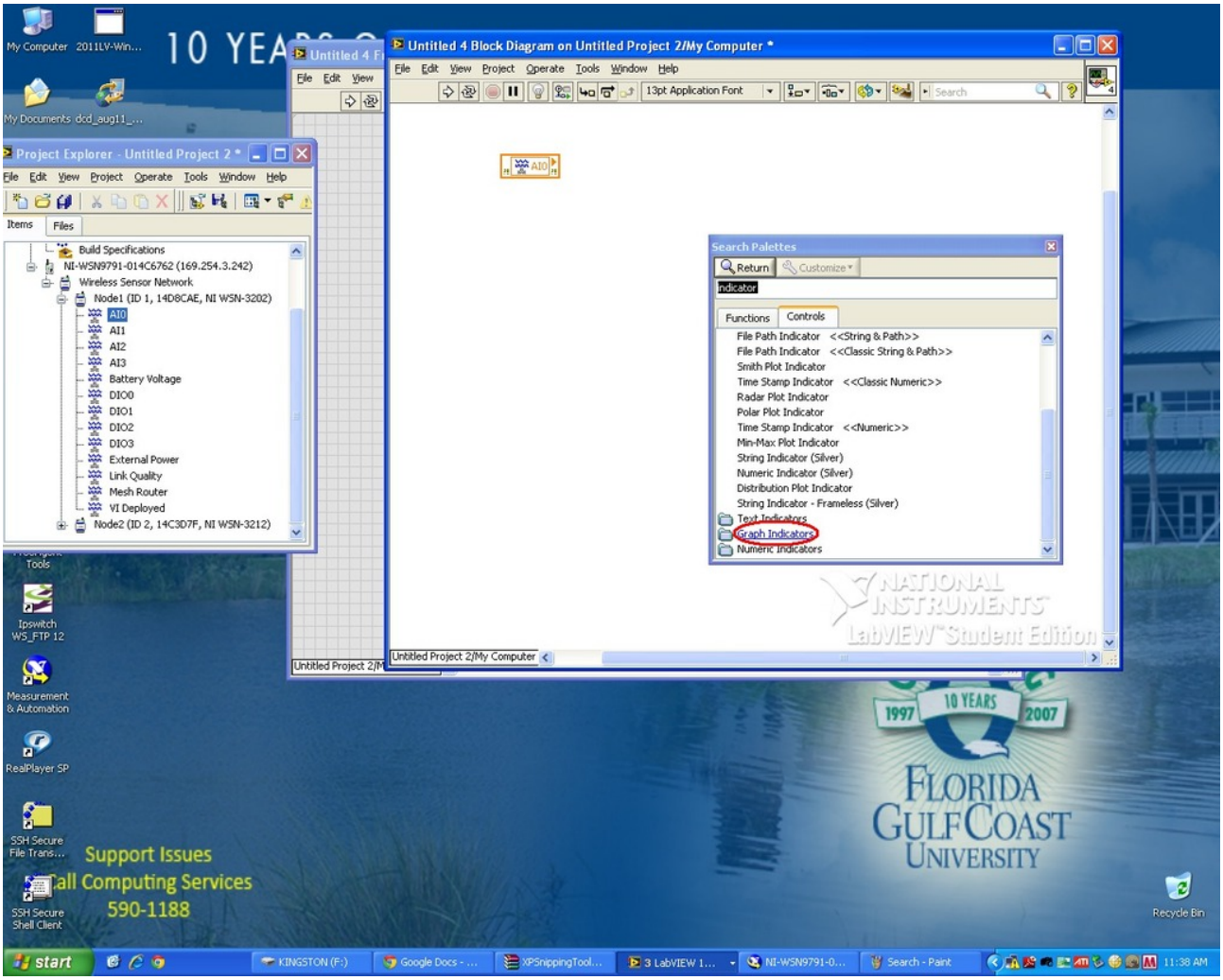
Untitled 4 Block Diagram on Untitled Project 2/My Computer *
Project Explorer - Untitled Project 2 *
Search Palettes
Graph Indicators
Support Issues
590-1188
FLORIDA GULF COAST UNIVERSITY

Fig. A17. Type in indicator. Double click the folder labeled Graph Indicators. A new group of items will be added to the Express Menu.

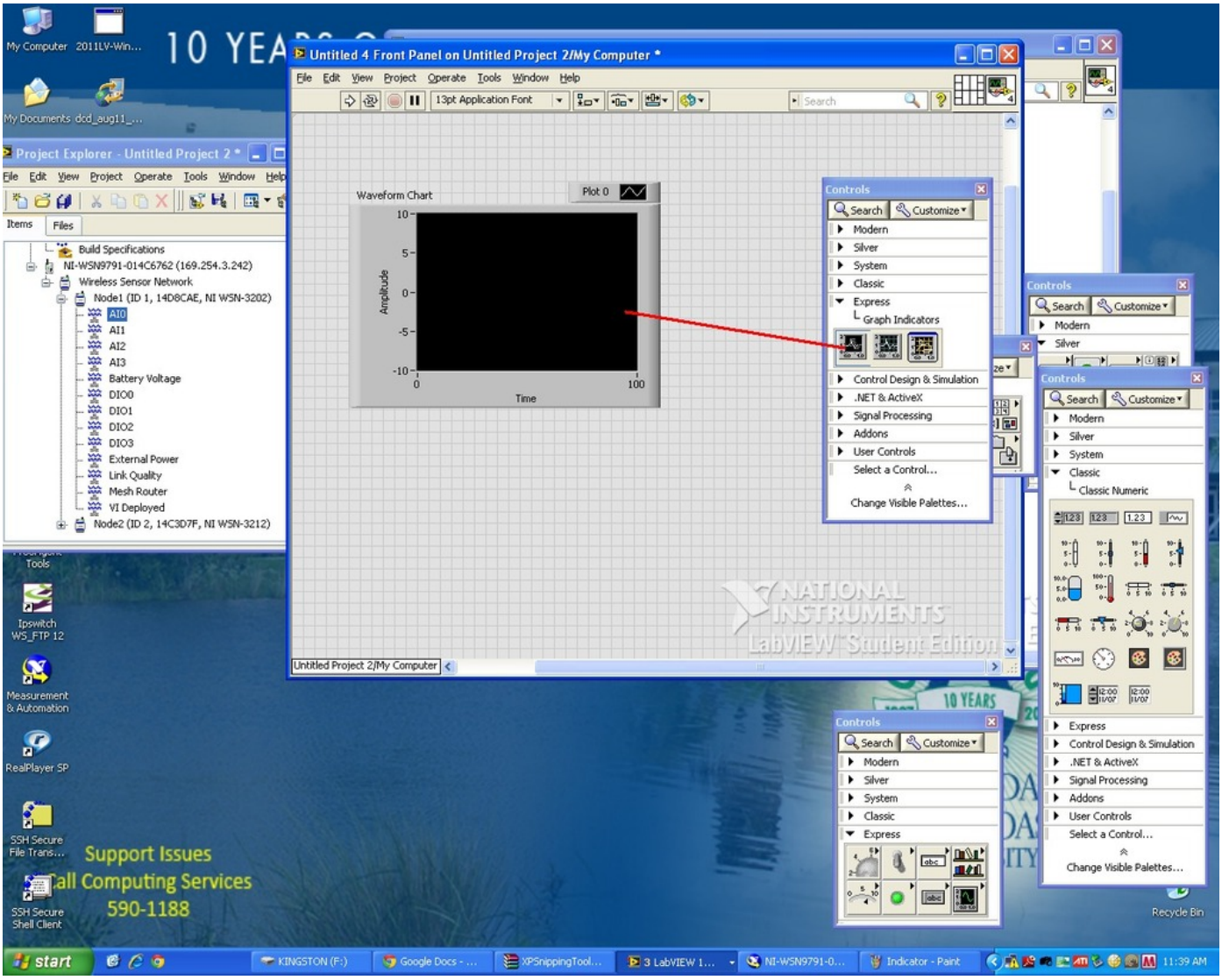

Fig. A18. Choose a Waveform Graph and drag it into the Front Panel.

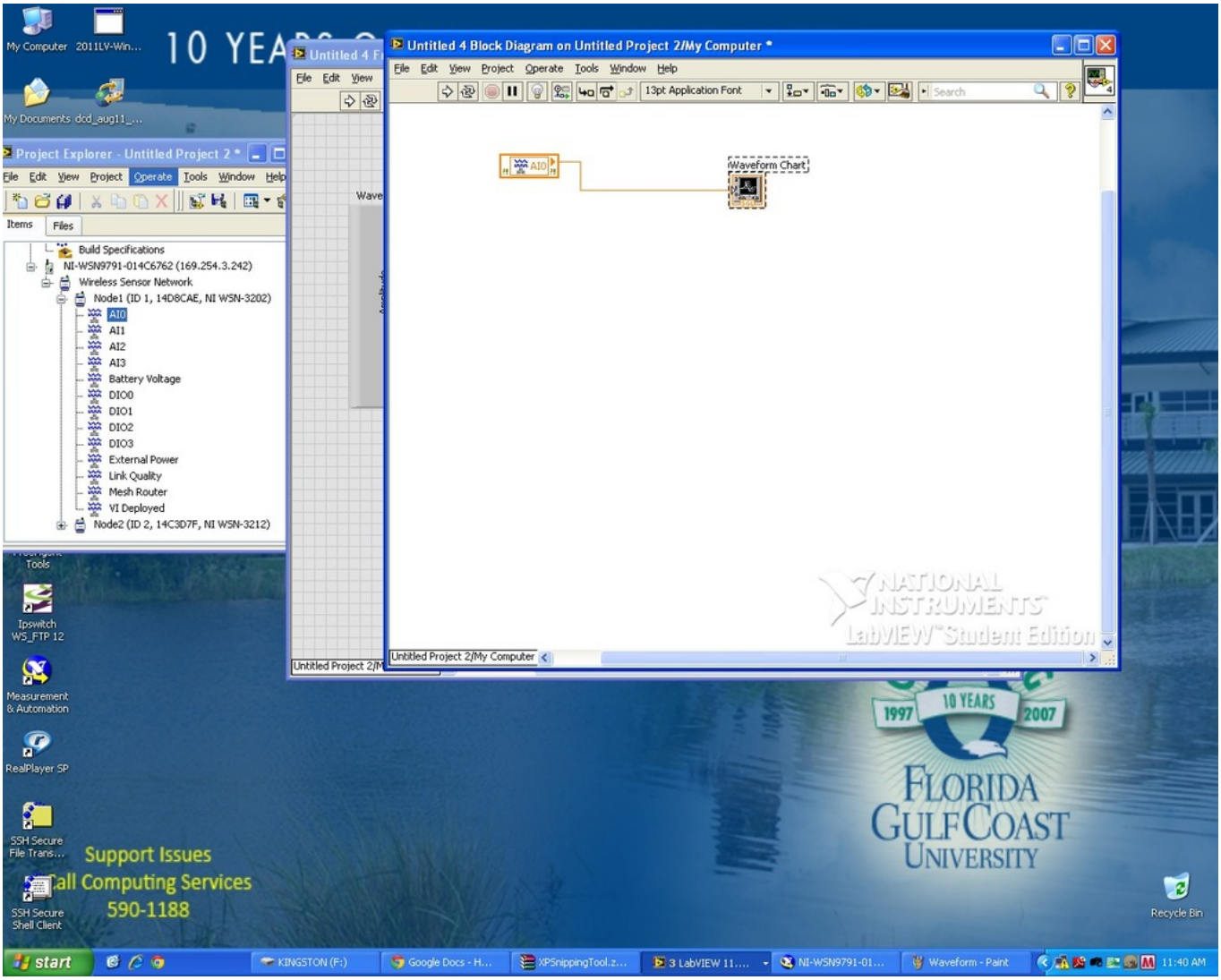

Fig. A19. Returning to the block diagram, create a wire between AI0 and the Waveform Indicator.

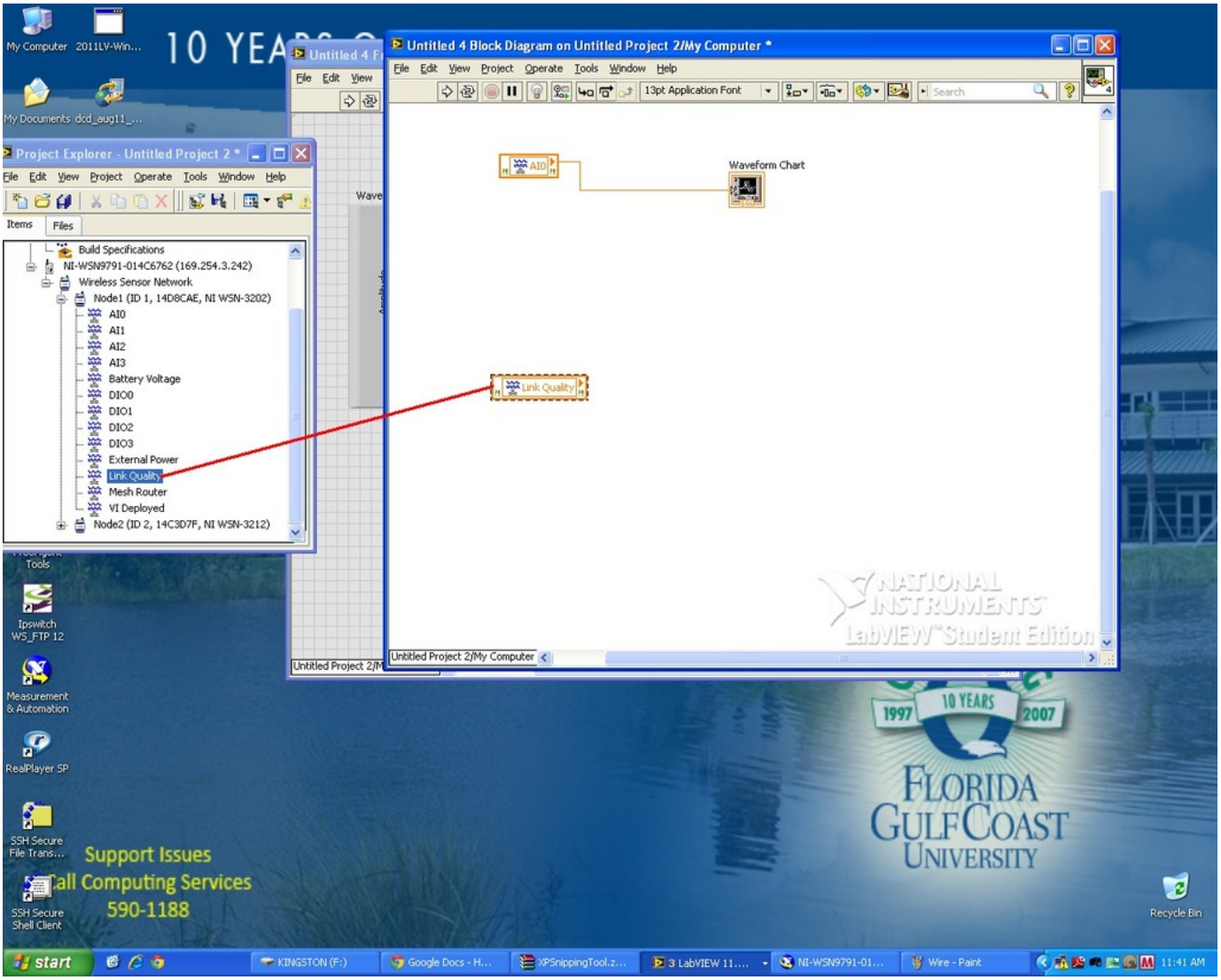

Fig. A20. Next, from the Project Explorer window, drag Link Quality onto the block diagram.

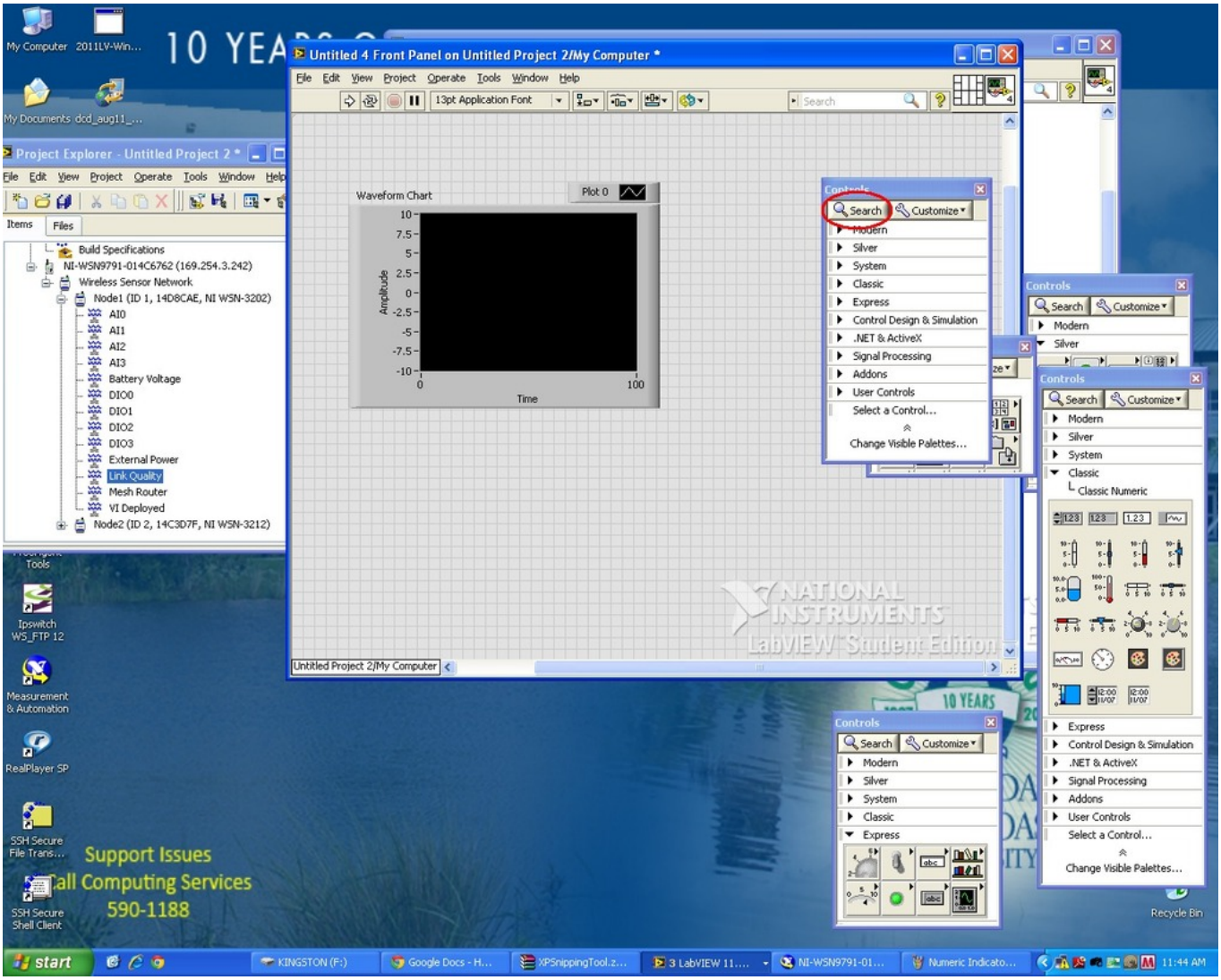

Fig. A21. In the front panel, right click and click the search button.

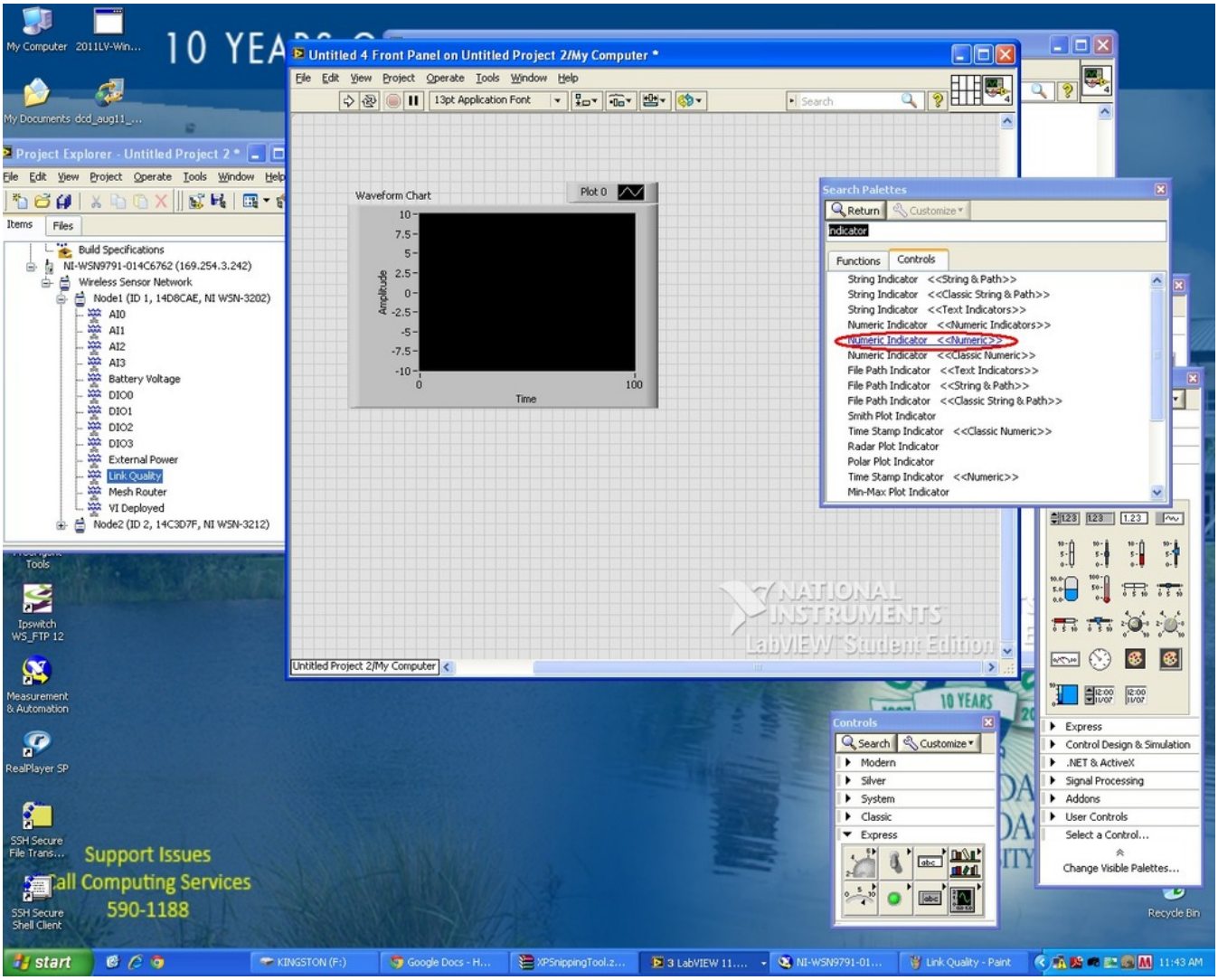

Fig. A22. Type in indicator. Double click the folder labeled Numeric Indicators.

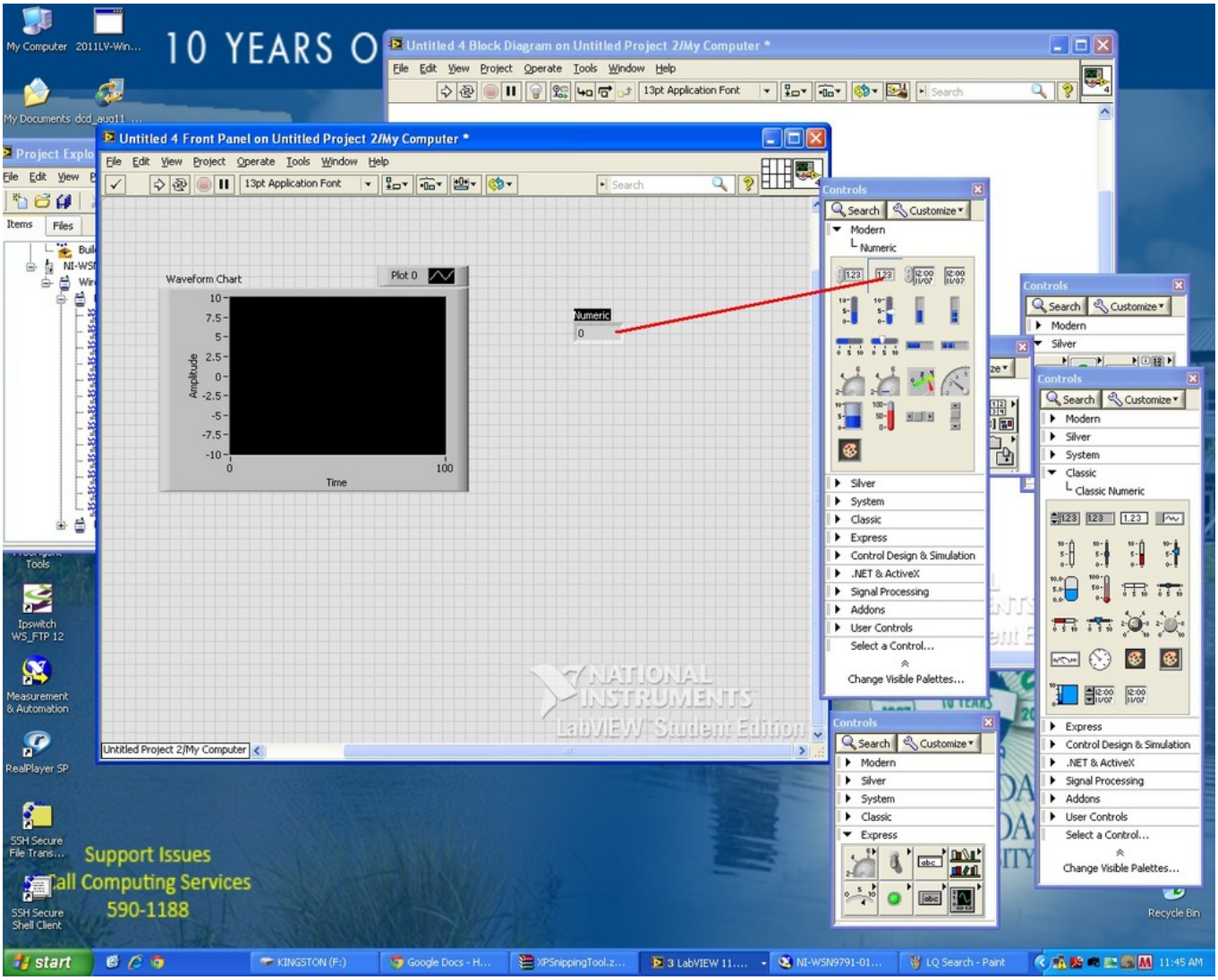

Fig. A23. Again, another group of items will appear in the Express menu. Drag any numeric indicator onto the Front Panel.

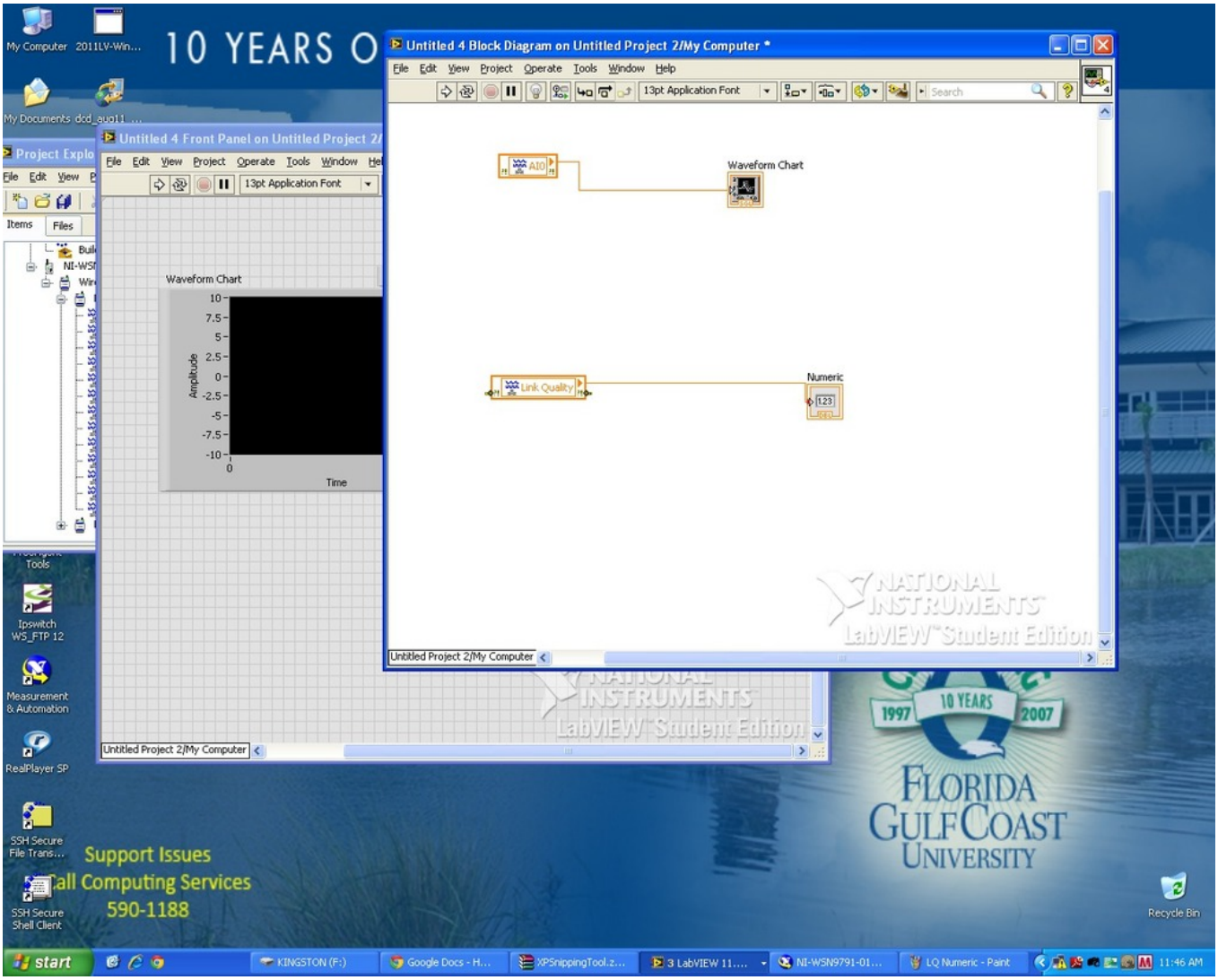

Fig. A24. Returning to the block diagram, create a wire between Link Quality and the Numeric Indicator.

A4. Running the LabVIEW Program and Troubleshooting:

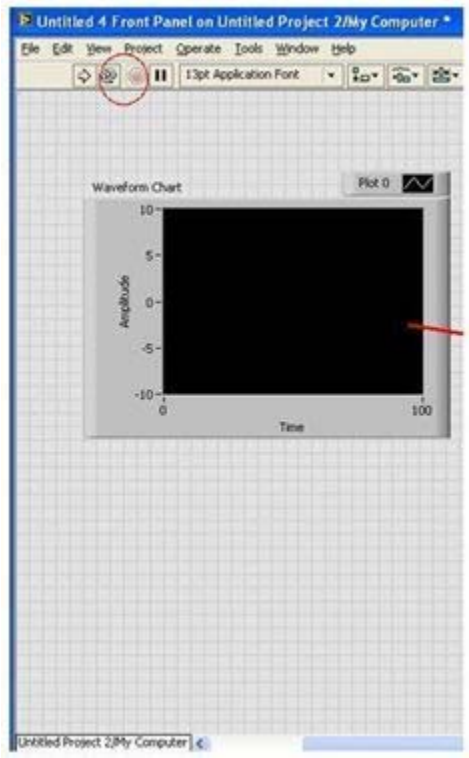

Fig. 25. Screen showing how to run the program.

To run the program, in the Front Panel, click the symbol of two arrows in a loop. This will cause the program to run until the stop button (orange octagon) is pressed.

If the program does not work properly, make sure of the following:

- All wires are correctly connected, both securely and in the right ports
- All LabVIEW program wires are properly connected (No red X's)
- The Ethernet gateway is connected and detected in both LabVIEW and Measurement and Automation.
- The wireless nodes have fresh, charged batteries.

For more help, visit: http://www.ni.com/support/